

## 20.7- and 31.4-GHz Solar Disk Temperature Measurements

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The 20.7/31.4 GHz Water Vapor Radiometer (WVR-R06) located at the JPL Mesa in Pasadena was used for atmospheric noise temperature measurements on March 24, 1981. The equivalent sun disk temperature measurements computed from the results of the previously reported sun antenna temperature measurements (Ref. 1) are:

Frequency, GHz	$T_{\text{sun}}, \text{K}$ (This report)	$T_{\text{sun}}, \text{K}$ (Ref. 6)
20.7	$10,530 \pm 210 (1\sigma)$	11,430
31.4	$9,170 \pm 250 (1\sigma)$	9,960

Comparison of the results of this report with Ref. 6 at the same frequency indicates satisfactory radiometer performance. The results of the horn antenna HPBW (half power beamwidth) evaluation indicate that the design goal of approximately equal beamwidths at 20.7 and 31.7 GHz was achieved.

### I. Introduction

The 20.7/31.4-GHz Water Vapor Radiometer (WVR-R06) located at the JPL Mesa in Pasadena was used for atmospheric noise temperature measurements on March 24, 1981 (Ref. 1). The on/off sun method used as an alternative method of atmospheric loss calibrations yielded estimates of the antenna sun temperature corrected for atmospheric loss. This report converts this data to equivalent solar disk temperatures. Comparison with other measurements can be used as an indication of radiometer performance. Measurements and analysis of the horn beamwidths are presented.

where

$$T_A = \text{antenna temperature contribution due to source, K}$$

$$\Omega_A = \text{antenna beam solid angle, rad}^2$$

$$\Omega_S = \text{source solid angle, rad}^2$$

The source solid angle is given by (sun radius  $\cong 0.270^\circ$  from the *Nautical Almanac* for 3/24/81)

$$\Omega_S = \Omega_{\text{sun}} \cong \pi r^2$$

$$= \pi(0.270)^2 / (57.296)^2$$

$$= 6.9764 \times 10^{-5}, \text{rad}^2 \quad (2)$$

$$T_S = T_A \Omega_A / \Omega_S \quad (1)$$

The beam solid angle of the horn antenna is given by (Ref. 3)

$$\Omega_A = 4\pi/G_M \quad (3)$$

where

$G_M$  = maximum antenna gain, power ratio

### III. Results

$G_M$  was computed for the 20.7- and 31.4-GHz WVR horns using P. Potter's computer program (Ref. 4)<sup>1</sup> as indicated on the last page of the computer printouts shown in Figs. 1 and 2. The previously reported (Ref. 1) sun noise temperature measurements made with the 20.7/31.4-GHz Water Vapor Radiometer (WVR-R06) located at the JPL Mesa in Pasadena were used in Eq. (1). The results are tabulated in Table 2. The reported errors are  $1\sigma$  statistical and do not represent overall measurement accuracy. The equivalent solar disk temperature (solar brightness temperature) results compare favorably

<sup>1</sup>For completeness, the computer program printouts for 20.7 and 31.4 GHz are shown in Figs. 1 and 2. Figures 3 and 4 show amplitude and phase plots of this data. Table 1 tabulates the dimensions of the WVR horns.

(Fig. 5 and Table 2) with Linsky (Ref. 6, Fig. 2, Eq. (3)), using his quadratic regression curve. This agreement indicates satisfactory radiometer performance. The HPBWs (half power beamwidths) of the antennas were evaluated by performing radio metric drift curves using the sun as a source<sup>2</sup> (experimental, Fig. 6) and by fitting a Gaussian curve to the computer-generated patterns (theoretical). The results are tabulated in Table 3. These indicate that the design goal for approximately equal HPBWs at 20.7 and 31.4 GHz was achieved. We have (Ref. 2, assuming  $\theta_{HPBW} = \phi_{HPBW}$ )

$$\Omega_A = \frac{k_p(\theta_{HPBW})^2}{\epsilon_M} = k(\theta_{HPBW})^2 \quad (4)$$

where  $k_p$  and  $\epsilon_M$  are defined in Ref. 2, pp. 220 and 221.

Using  $\Omega_A$  tabulated in Table 2 results in the values for  $k$  shown in brackets in Table 3. These results for  $k$  are consistent with values of 1.33 and 1.51 obtained with uniform and Gaussian illuminations of an antenna aperture (Refs. 2 and 3).

<sup>2</sup>This was performed at 20.7 and 31.4 GHz using the WVR-R04 located at the JPL DSS 13 Goldstone station. The measurements were made at meridian crossing so the antenna could be moved ahead of the sun by moving only the azimuth coordinate (since the AZ-EL antenna mount is manually controlled). The results were not corrected for finite source size.

## Acknowledgments

R. Clauss suggested converting the previously measured solar antenna temperature results to an equivalent solar disk temperature. D. Bathker, V. Galindo, and B. Seidel provided useful suggestions. T. Otoshi generated Ref. 3, which was especially useful in this report. W. Williams supplied the antenna computer output. E. Woods, Jr. (Petersen Instruments, Inc.), N. Yamane, and G. Resch supplied the horn dimensions.

## References

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3. Otoshi, T., "Relationship of Beam Solid Angle to Antenna Half Power Beamwidths," in *The Telecommunications and Data Acquisition Progress Report 42-64* (this issue).
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6. Linsky, J. L., "A Recalibration of the Quiet Sun Millimeter Spectrum Based on the Moon as an Absolute Radiometric Standard," *Solar Physics*, Vol. 28, pp. 419-424, 1973.

**Table 1.** Horn dimensions for the original 33.0-GHz design (Ref. 5), scaled to 21.0 GHz for use at 20.7 GHz; the original 33-GHz design is used at 31.4 GHz

	Dimensions	
Operating frequency, GHz	20.7	31.4
Design frequency, GHz	21.0	33.0
Length of phasing section, in.	0.000	0.000
Diameter at input, in.	0.588	0.380
Axial length of flare, in.	19.675	12.451
Aperture diameter, in.	7.417	4.720
Groove depth, in.	0.196	0.125
Flare half angle, deg	9.883	9.883

**Table 2.** Tabulation of 20.7/31.4-GHz WVR computed horn parameters and results of Mesa, Pasadena, sun measurements

Frequency GHz	Computed $G_M$ , dB	Computed $\Omega_A$ , rad <sup>2</sup> (Eq. 3)	Measured $^* \Delta T_{sun}$ , K (Ref. 1)	$T_{sun}$ , K (This article)	$T_{sun}$ , K (Ref. 6)
20.7	27.785	0.020927	$35.1 \pm 0.7$ ( $1\sigma$ )	$10,530 \pm 210$ ( $1\sigma$ )	11,430
31.4	27.658	0.021548	$29.7 \pm 0.8$ ( $1\sigma$ )	$9170 \pm 250$ ( $1\sigma$ )	9,960

\*Same as  $T_A$  in Eq. (1)

**Table 3.** Tabulation of WVR horn beamwidth (HPBW) and  $k$  value (defined Eq. 4)

Frequency, GHz	WVR horn beamwidth (HPBW), deg	
	Experimental	Theoretical
20.7	6.875 ( $k \cong 1.453$ )	6.881 ( $k \cong 1.451$ )
	6.775 ( $k \cong 1.541$ )	7.016 ( $k \cong 1.437$ )
31.4		

HYBRID MODE HORN PROGRAM

7.417 INCH, APERTURE, 19.675 INCH LONG, 0.196 INCH GROOVES 9.883 DEG FLARE

ALL DIMENSIONS IN INCHES

CARD OUTPUT FOR FAR-FIELDS

LENGTH OF PHASING SECTION= .00000

DIAMETER OF PHASING SECTION= .58800

AXIAL LENGTH OF FLARE SECTION= 19.67500

APERTURE DIAMETER= 7.41700

GROOVE DEPTH= .19600

THE FARFIELD PHASE REFERENCE POINT IS .00000 INSIDE THE HORN APERTURE

FLARE SECTION HALF ANGLE= 9.84534 DEGREES

RADIUS FROM VERTEX TO APERTURE CAP= 21.66849

SPECIFIED FREQUENCY= 20.70000 GHZ.

NUMBER OF POINTS USED IN FLARE SECTION PHASE SHIFT INTEGRATION= 11

MODE PHASES AT BEGINNING OF PHASING SECTION  
AND APERTURE LONGITUDINAL FIELD AMPLITUDES

HE MODES

MODE	VOLTS	DEG
1	1.00000	.00000

EH MODES

	VOLTS	DEG
	.00000	.00000

Fig. 1. 20.7-GHz horn computer printout

## ANTENNA FEED EFFICIENCY

FREQ., 20.7GHZ, GROOVES #0.3438 LAMBDA

0

7.417 INCH, APERTURE, 19.675 INCH LONG, 0.196 INCH GROOVES 9.883 DEG FLARE

THETA	ETA T (OVERALL)	ETA S (SPILL)	ETA I (ILLUM)	ETA X (X-POL.)	ETA P (PHASE)	ETA B (BLOCK)	ETA M (M=1)
1.000	.04425	.04423	.99992	1.00069	1.00000	1.00000	1.00000
2.000	.16146	.16161	.99869	1.00038	1.00000	1.00000	1.00000
3.000	.31386	.31579	.99381	1.00009	1.00000	1.00000	1.00000
4.000	.46182	.47021	.98236	.99984	.99995	1.00000	1.00000
5.000	.58109	.60374	.96304	.99974	.99968	1.00000	1.00000
6.000	.66638	.71180	.93720	.99977	.99915	1.00000	1.00000
7.000	.72238	.79749	.90711	.99983	.99875	1.00000	1.00000
8.000	.75290	.86353	.87304	.99986	.99879	1.00000	1.00000
9.000	.75788	.91104	.83312	.99984	.99867	1.00000	1.00000
10.000	.73844	.94214	.78582	.99980	.99762	1.00000	1.00000
11.000	.70152	.96132	.73297	.99979	.99581	1.00000	1.00000
12.000	.65717	.97360	.67951	.99981	.99355	1.00000	1.00000
13.000	.61163	.98225	.62927	.99983	.98971	1.00000	1.00000
14.000	.56496	.98838	.58232	.99963	.98177	1.00000	1.00000
15.000	.51599	.99226	.53692	.99982	.96870	1.00000	1.00000
16.000	.46705	.99447	.49287	.99961	.95306	1.00000	1.00000
17.000	.42160	.99584	.45211	.99982	.93657	1.00000	1.00000
18.000	.37984	.99694	.41615	.99982	.91572	1.00000	1.00000
19.000	.34001	.99782	.38423	.99982	.88701	1.00000	1.00000
20.000	.30266	.99839	.35473	.99982	.85475	1.00000	1.00000
21.000	.26980	.99870	.32711	.99982	.82602	1.00000	1.00000
22.000	.24136	.99891	.30217	.99982	.79976	1.00000	1.00000
23.000	.21633	.99913	.28035	.99982	.77245	1.00000	1.00000
24.000	.19544	.99933	.26093	.99982	.74965	1.00000	1.00000
25.000	.17908	.99945	.24293	.99982	.73772	1.00000	1.00000
26.000	.16577	.99952	.22611	.99982	.73363	1.00000	1.00000
27.000	.15445	.99957	.21091	.99982	.73278	1.00000	1.00000
28.000	.14479	.99964	.19749	.99982	.73354	1.00000	1.00000
29.000	.13546	.99970	.18538	.99982	.73107	1.00000	1.00000
30.000	.12588	.99974	.17406	.99982	.72350	1.00000	1.00000
31.000	.11683	.99976	.16340	.99982	.71526	1.00000	1.00000
32.000	.10860	.99978	.15367	.99982	.70703	1.00000	1.00000
33.000	.10148	.99981	.14496	.99982	.70030	1.00000	1.00000
34.000	.09575	.99983	.13705	.99982	.69888	1.00000	1.00000
35.000	.09053	.99985	.12962	.99982	.69868	1.00000	1.00000
36.000	.08527	.99986	.12254	.99982	.69604	1.00000	1.00000
37.000	.08015	.99987	.11596	.99982	.69140	1.00000	1.00000
38.000	.07535	.99988	.11000	.99982	.68527	1.00000	1.00000
39.000	.07134	.99989	.10456	.99982	.68243	1.00000	1.00000
40.000	.06785	.99991	.09948	.99982	.68219	1.00000	1.00000
41.000	.06429	.99991	.09462	.99982	.67960	1.00000	1.00000
42.000	.06081	.99991	.08999	.99982	.67594	1.00000	1.00000
43.000	.05765	.99992	.08569	.99982	.67292	1.00000	1.00000
44.000	.05495	.99992	.08176	.99982	.67221	1.00000	1.00000
45.000	.05238	.99993	.07813	.99982	.67063	1.00000	1.00000

Fig. 1 (contd)

THETA	ETA T (OVERALL)	ETA S (SPILL)	ETA I (ILLUM)	ETA X (X-POL)	ETA P (PHASE)	ETA B (BLOCK)	ETA M (M=1)
46.000	.04973	.99994	.07470	.99982	.66591	1.00000	1.00000
47.000	.04736	.99994	.07139	.99982	.66350	1.00000	1.00000
48.000	.04526	.99994	.06822	.99982	.66365	1.00000	1.00000
49.000	.04323	.99994	.06524	.99981	.66279	1.00000	1.00000
50.000	.04119	.99995	.06249	.99981	.65935	1.00000	1.00000
51.000	.03939	.99995	.05993	.99981	.65733	1.00000	1.00000
52.000	.03775	.99996	.05752	.99981	.65635	1.00000	1.00000
53.000	.03606	.99996	.05522	.99981	.65316	1.00000	1.00000
54.000	.03451	.99996	.05298	.99981	.65156	1.00000	1.00000
55.000	.03311	.99996	.05083	.99981	.65165	1.00000	1.00000
56.000	.03172	.99996	.04879	.99981	.65028	1.00000	1.00000
57.000	.03039	.99996	.04690	.99981	.64814	1.00000	1.00000
58.000	.02921	.99997	.04512	.99981	.64743	1.00000	1.00000
59.000	.02801	.99997	.04344	.99981	.64492	1.00000	1.00000
60.000	.02688	.99997	.04184	.99981	.64264	1.00000	1.00000
61.000	.02586	.99997	.04030	.99981	.64186	1.00000	1.00000
62.000	.02483	.99997	.03880	.99981	.64006	1.00000	1.00000
63.000	.02387	.99997	.03735	.99981	.63936	1.00000	1.00000
64.000	.02298	.99998	.03595	.99981	.63920	1.00000	1.00000
65.000	.02208	.99998	.03464	.99981	.63766	1.00000	1.00000
66.000	.02126	.99998	.03340	.99981	.63683	1.00000	1.00000
67.000	.02047	.99998	.03223	.99981	.63538	1.00000	1.00000
68.000	.01970	.99998	.03111	.99981	.63332	1.00000	1.00000
69.000	.01899	.99998	.03005	.99981	.63222	1.00000	1.00000
70.000	.01828	.99998	.02902	.99981	.63007	1.00000	1.00000
71.000	.01763	.99998	.02803	.99981	.62893	1.00000	1.00000
72.000	.01699	.99999	.02707	.99981	.62761	1.00000	1.00000
73.000	.01637	.99999	.02614	.99981	.62646	1.00000	1.00000
74.000	.01580	.99999	.02524	.99981	.62603	1.00000	1.00000
75.000	.01523	.99999	.02436	.99981	.62518	1.00000	1.00000
76.000	.01469	.99999	.02351	.99981	.62501	1.00000	1.00000
77.000	.01417	.99999	.02270	.99981	.62427	1.00000	1.00000
78.000	.01367	.99999	.02193	.99981	.62363	1.00000	1.00000
79.000	.01320	.99999	.02119	.99981	.62283	1.00000	1.00000
80.000	.01273	.99999	.02049	.99981	.62170	1.00000	1.00000
81.000	.01229	.99999	.01981	.99981	.62083	1.00000	1.00000
82.000	.01186	.99999	.01916	.99981	.61944	1.00000	1.00000
83.000	.01146	.99999	.01853	.99981	.61847	1.00000	1.00000
84.000	.01106	.99999	.01793	.99981	.61700	1.00000	1.00000
85.000	.01068	.99999	.01734	.99981	.61595	1.00000	1.00000
86.000	.01031	.99999	.01678	.99981	.61454	1.00000	1.00000
87.000	.00996	.99999	.01624	.99981	.61342	1.00000	1.00000
88.000	.00961	.99999	.01571	.99981	.61213	1.00000	1.00000
89.000	.00929	.99999	.01520	.99981	.61099	1.00000	1.00000
90.000	.00897	.99999	.01471	.99981	.60982	1.00000	1.00000
91.000	.00866	1.00000	.01423	.99981	.60870	1.00000	1.00000
92.000	.00836	1.00000	.01376	.99981	.60764	1.00000	1.00000
93.000	.00807	1.00000	.01331	.99981	.60657	1.00000	1.00000
94.000	.00780	1.00000	.01288	.99981	.60561	1.00000	1.00000
95.000	.00753	1.00000	.01245	.99981	.60460	1.00000	1.00000
96.000	.00727	1.00000	.01204	.99981	.60372	1.00000	1.00000
97.000	.00702	1.00000	.01165	.99981	.60277	1.00000	1.00000
98.000	.00678	1.00000	.01126	.99981	.60195	1.00000	1.00000

Fig. 1 (contd)

THETA	ETA T (OVERALL)	ETA S (SPILL)	ETA I (ILLUM)	ETA X (X-POL.)	ETA P (PHASE)	ETA B (BLOCK)	ETA M (M=1)
99.000	.00654	1.00000	.01088	.99981	.60107	1.00000	1.00000
100.000	.00631	1.00000	.01052	.99981	.60031	1.00000	1.00000
101.000	.00609	1.00000	.01017	.99981	.59950	1.00000	1.00000
102.000	.00588	1.00000	.00982	.99981	.59880	1.00000	1.00000
103.000	.00567	1.00000	.00949	.99981	.59806	1.00000	1.00000
104.000	.00547	1.00000	.00916	.99981	.59740	1.00000	1.00000
105.000	.00528	1.00000	.00885	.99981	.59673	1.00000	1.00000
106.000	.00509	1.00000	.00854	.99981	.59612	1.00000	1.00000
107.000	.00491	1.00000	.00825	.99981	.59551	1.00000	1.00000
108.000	.00473	1.00000	.00796	.99981	.59495	1.00000	1.00000
109.000	.00456	1.00000	.00768	.99981	.59440	1.00000	1.00000
110.000	.00440	1.00000	.00740	.99981	.59389	1.00000	1.00000
111.000	.00424	1.00000	.00714	.99981	.59339	1.00000	1.00000
112.000	.00408	1.00000	.00688	.99981	.59292	1.00000	1.00000
113.000	.00393	1.00000	.00663	.99981	.59247	1.00000	1.00000
114.000	.00378	1.00000	.00639	.99981	.59204	1.00000	1.00000
115.000	.00364	1.00000	.00615	.99981	.59164	1.00000	1.00000
116.000	.00350	1.00000	.00592	.99981	.59125	1.00000	1.00000
117.000	.00337	1.00000	.00570	.99981	.59090	1.00000	1.00000
118.000	.00324	1.00000	.00548	.99981	.59054	1.00000	1.00000
119.000	.00311	1.00000	.00527	.99981	.59023	1.00000	1.00000
120.000	.00299	1.00000	.00507	.99981	.58990	1.00000	1.00000
121.000	.00287	1.00000	.00487	.99981	.58962	1.00000	1.00000
122.000	.00276	1.00000	.00468	.99981	.58932	1.00000	1.00000
123.000	.00264	1.00000	.00449	.99981	.58907	1.00000	1.00000
124.000	.00253	1.00000	.00431	.99981	.58879	1.00000	1.00000
125.000	.00243	1.00000	.00413	.99981	.58858	1.00000	1.00000
126.000	.00233	1.00000	.00396	.99981	.58833	1.00000	1.00000
127.000	.00223	1.00000	.00379	.99981	.58812	1.00000	1.00000
128.000	.00213	1.00000	.00363	.99981	.58790	1.00000	1.00000
129.000	.00204	1.00000	.00347	.99981	.58771	1.00000	1.00000
130.000	.00195	1.00000	.00332	.99981	.58752	1.00000	1.00000
131.000	.00186	1.00000	.00317	.99981	.58734	1.00000	1.00000
132.000	.00178	1.00000	.00303	.99981	.58717	1.00000	1.00000
133.000	.00170	1.00000	.00289	.99981	.58699	1.00000	1.00000
134.000	.00162	1.00000	.00275	.99981	.58686	1.00000	1.00000
135.000	.00154	1.00000	.00262	.99981	.58668	1.00000	1.00000
136.000	.00146	1.00000	.00250	.99981	.58657	1.00000	1.00000
137.000	.00139	1.00000	.00237	.99981	.58639	1.00000	1.00000
138.000	.00132	1.00000	.00225	.99981	.58629	1.00000	1.00000
139.000	.00125	1.00000	.00214	.99981	.58614	1.00000	1.00000
140.000	.00119	1.00000	.00203	.99981	.58603	1.00000	1.00000
141.000	.00112	1.00000	.00192	.99981	.58591	1.00000	1.00000
142.000	.00106	1.00000	.00182	.99981	.58579	1.00000	1.00000
143.000	.00100	1.00000	.00171	.99981	.58570	1.00000	1.00000
144.000	.00095	1.00000	.00162	.99981	.58557	1.00000	1.00000
145.000	.00089	1.00000	.00152	.99981	.58549	1.00000	1.00000
146.000	.00084	1.00000	.00143	.99981	.58536	1.00000	1.00000
147.000	.00079	1.00000	.00134	.99981	.58529	1.00000	1.00000
148.000	.00074	1.00000	.00126	.99981	.58518	1.00000	1.00000
149.000	.00069	1.00000	.00118	.99981	.58509	1.00000	1.00000
150.000	.00064	1.00000	.00110	.99981	.58501	1.00000	1.00000
151.000	.00060	1.00000	.00103	.99981	.58489	1.00000	1.00000

Fig. 1 (contd)

THETA	ETA T (OVERALL)	ETA S (SPILL)	ETA I (ILLUM)	ETA X (X=POL.)	ETA P (PHASE)	ETA B (BLOCK)	ETA M (M=1)
152.000	.00056	1.00000	.00095	.99981	.58485	1.00000	1.00000
153.000	.00052	1.00000	.00088	.99981	.58473	1.00000	1.00000
154.000	.00048	1.00000	.00082	.99981	.58467	1.00000	1.00000
155.000	.00044	1.00000	.00075	.99981	.58458	1.00000	1.00000
156.000	.00041	1.00000	.00069	.99981	.58449	1.00000	1.00000
157.000	.00037	1.00000	.00064	.99981	.58444	1.00000	1.00000
158.000	.00034	1.00000	.00058	.99981	.58432	1.00000	1.00000
159.000	.00031	1.00000	.00053	.99981	.58428	1.00000	1.00000
160.000	.00028	1.00000	.00048	.99981	.58420	1.00000	1.00000
161.000	.00025	1.00000	.00043	.99981	.58411	1.00000	1.00000
162.000	.00022	1.00000	.00039	.99981	.58407	1.00000	1.00000
163.000	.00020	1.00000	.00034	.99981	.58396	1.00000	1.00000
164.000	.00018	1.00000	.00030	.99981	.58392	1.00000	1.00000
165.000	.00016	1.00000	.00027	.99981	.58384	1.00000	1.00000
166.000	.00014	1.00000	.00023	.99981	.58370	1.00000	1.00000
167.000	.00012	1.00000	.00020	.99981	.58369	1.00000	1.00000
168.000	.00010	1.00000	.00017	.99981	.58357	1.00000	1.00000
169.000	.00008	1.00000	.00014	.99981	.58345	1.00000	1.00000
170.000	.00007	1.00000	.00012	.99981	.58343	1.00000	1.00000
171.000	.00006	1.00000	.00010	.99981	.58326	1.00000	1.00000
172.000	.00004	1.00000	.00008	.99981	.58314	1.00000	1.00000
173.000	.00003	1.00000	.00006	.99981	.58308	1.00000	1.00000
174.000	.00002	1.00000	.00004	.99981	.58283	1.00000	1.00000
175.000	.00002	1.00000	.00003	.99981	.58271	1.00000	1.00000
176.000	.00001	1.00000	.00002	.99981	.58252	1.00000	1.00000
177.000	.00001	1.00000	.00001	.99981	.58204	1.00000	1.00000
178.000	.00000	1.00000	.00000	.99981	.58182	1.00000	1.00000
179.000	.00000	1.00000	.00000	.99981	.58046	1.00000	1.00000
180.000	.00000	1.00000	.00000	.99981	.00138	1.00000	1.00000
MAXIMUM EFFICIENCY			F/D = 3.285				
8.704	.75895	.89867	.84573	.99984	.99880	1.00000	1.00000
GAIN = 27.785 DB = 600.482 = $G_M$ ← FEED BLOCKAGE ANGLE = .000 DEGREES TOTAL RADIATED POWER FOR GIVEN PATTERN = .277858-04 WATTS TOTAL RADIATED POWER REFERENCE PATTERN = .277858-04 WATTS ETAR = 1.00000 (GIVEN PAT. POWER / REF. PAT. POWER) NUMBER OF TERMS USED IN INTERPOLATIONS = 3							
EFFICIENCY CALCULATED FOR M = (1, EVEN) CASE ONLY							
FREQ=.20.7GHZ, GROOVES=0.3438 LAMBDA							
7.417 INCH, APERTURE, 19.675 INCH LONG, 0.196 INCH GROOVES 9.883 DEG FLARE							

Fig. 1 (contd)

HYBRID MODE HORN PROGRAM

4.720INCH APERTURE, 12.45INCH LONG, .125INCH GROOVES, 9.883 DEG FLARE

ALL DIMENSIONS IN INCHES

CARD OUTPUT FOR FAR-FIELDS

LENGTH OF PHASING SECTION= .00000

DIAMETER OF PHASING SECTION= .38000

AXIAL LENGTH OF FLARE SECTION= 12.45100

APERTURE DIAMETER= 4.72000

GROOVE DEPTH= .12500

THE FAR-FIELD PHASE REFERENCE POINT IS .00000 INSIDE THE HORN APERTURE

FLARE SECTION HALF ANGLE= 9.88639 DEGREES

RADIUS FROM VERTEX TO APERTURE CAP= 13.74530

SPECIFIED FREQUENCY= 31.40000 GHZ.

NUMBER OF POINTS USED IN FLARE SECTION PHASE SHIFT INTEGRATION= 11

MODE PHASES AT BEGINNING OF PHASING SECTION  
AND APERTURE LONGITUDINAL FIELD AMPLITUDES

HE MODES

MODE	VOLTS	DEG
1	1.00000	.00000

EH MODES

	VOLTS	DEG
	.00000	.00000

Fig. 2. 31.4-GHz horn computer printout

### ANTENNA FEED EFFICIENCY

FREQ=.31.4GHZ, GROOVES=.3263LAMBDA

0

4.720INCH, APERTURE=12.45INCH LONG=.125INCH GROOVES,.9.883 DEG FLARE

THETA	ETA T (OVERALL)	ETA S (SPILL)	ETA I (ILLUM)	ETA X (X-POL)	ETA P (PHASE)	ETA B (BLOCK)	ETA M (M=1)
1.000	.04306	.04304	.99993	1.00063	1.00000	1.00000	1.00000
2.000	.15774	.15792	.99881	1.00037	.99999	1.00000	1.00000
3.000	.30855	.31028	.99432	1.00012	.99999	1.00000	1.00000
4.000	.45665	.46436	.98352	.99980	.99999	1.00000	1.00000
5.000	.57675	.59808	.96471	.99976	.99987	1.00000	1.00000
6.000	.66196	.70567	.93875	.99976	.99950	1.00000	1.00000
7.000	.71706	.74042	.90814	.99982	.99909	1.00000	1.00000
8.000	.74784	.85627	.87435	.99986	.99902	1.00000	1.00000
9.000	.75582	.90502	.83609	.99986	.99902	1.00000	1.00000
10.000	.74111	.93812	.79151	.99982	.99825	1.00000	1.00000
11.000	.70780	.95886	.74086	.99980	.99656	1.00000	1.00000
12.000	.66455	.97175	.68782	.99981	.99445	1.00000	1.00000
13.000	.61926	.98052	.63697	.99983	.99168	1.00000	1.00000
14.000	.57431	.98692	.59098	.99984	.98634	1.00000	1.00000
15.000	.52815	.99133	.54587	.99984	.97617	1.00000	1.00000
16.000	.48075	.99399	.50294	.99983	.96182	1.00000	1.00000
17.000	.43513	.99552	.46195	.99983	.94635	1.00000	1.00000
18.000	.39352	.99658	.42482	.99983	.92967	1.00000	1.00000
19.000	.35492	.99747	.39224	.99983	.90730	1.00000	1.00000
20.000	.31799	.99817	.36302	.99983	.87771	1.00000	1.00000
21.000	.28392	.99861	.33577	.99983	.84691	1.00000	1.00000
22.000	.25429	.99884	.31032	.99983	.82053	1.00000	1.00000
23.000	.22850	.99902	.28746	.99983	.79583	1.00000	1.00000
24.000	.20582	.99922	.26743	.99983	.77036	1.00000	1.00000
25.000	.18706	.99939	.24950	.99983	.75034	1.00000	1.00000
26.000	.17235	.99950	.23282	.99983	.74077	1.00000	1.00000
27.000	.16018	.99955	.21718	.99983	.73799	1.00000	1.00000
28.000	.14966	.99960	.20298	.99983	.73774	1.00000	1.00000
29.000	.14054	.99966	.19041	.99983	.73847	1.00000	1.00000
30.000	.13168	.99972	.17909	.99983	.73560	1.00000	1.00000
31.000	.12254	.99976	.16853	.99983	.72740	1.00000	1.00000
32.000	.11392	.99978	.15853	.99983	.71887	1.00000	1.00000
33.000	.10617	.99979	.14927	.99983	.71150	1.00000	1.00000
34.000	.09938	.99981	.14095	.99983	.70533	1.00000	1.00000
35.000	.09386	.99984	.13344	.99983	.70366	1.00000	1.00000
36.000	.08894	.99986	.12645	.99983	.70354	1.00000	1.00000
37.000	.08389	.99987	.11980	.99983	.70051	1.00000	1.00000
38.000	.07897	.99988	.11349	.99983	.69607	1.00000	1.00000
39.000	.07437	.99988	.10768	.99483	.69086	1.00000	1.00000
40.000	.07037	.99990	.10242	.99983	.68733	1.00000	1.00000
41.000	.06702	.99991	.09757	.99983	.68708	1.00000	1.00000
42.000	.06367	.99992	.09299	.99983	.68484	1.00000	1.00000
43.000	.06028	.99992	.08860	.99483	.68052	1.00000	1.00000
44.000	.05718	.99993	.08440	.99483	.67762	1.00000	1.00000
45.000	.05446	.99993	.08051	.99983	.67659	1.00000	1.00000

Fig. 2 (contd)

THETA	ETA T (OVERALL)	ETA S (SPILL)	ETA I (ILLUM)	ETA X (X-POL)	ETA P (PHASE)	ETA B (BLOCK)	ETA M (M#1)
46.000	.05203	.99993	.07694	.99983	.67635	1.00000	1.00000
47.000	.04952	.99994	.07363	.99983	.67264	1.00000	1.00000
48.000	.04709	.99995	.07051	.99983	.66803	1.00000	1.00000
49.000	.04503	.99995	.06751	.99983	.66714	1.00000	1.00000
50.000	.04308	.99995	.06460	.99983	.66692	1.00000	1.00000
51.000	.04113	.99995	.06185	.99983	.66511	1.00000	1.00000
52.000	.03926	.99996	.05928	.99983	.66244	1.00000	1.00000
53.000	.03764	.99996	.05690	.99983	.66165	1.00000	1.00000
54.000	.03607	.99996	.05467	.99983	.65997	1.00000	1.00000
55.000	.03448	.99997	.05255	.99983	.65616	1.00000	1.00000
56.000	.03308	.99997	.05052	.99983	.65493	1.00000	1.00000
57.000	.03176	.99997	.04854	.99983	.65437	1.00000	1.00000
58.000	.03043	.99997	.04663	.99983	.65273	1.00000	1.00000
59.000	.02920	.99997	.04482	.99983	.65167	1.00000	1.00000
60.000	.02808	.99997	.04312	.99982	.65141	1.00000	1.00000
61.000	.02695	.99997	.04153	.99982	.64917	1.00000	1.00000
62.000	.02589	.99998	.04003	.99982	.64697	1.00000	1.00000
63.000	.02493	.99998	.03860	.99982	.64609	1.00000	1.00000
64.000	.02394	.99998	.03722	.99982	.64340	1.00000	1.00000
65.000	.02304	.99998	.03590	.99982	.64204	1.00000	1.00000
66.000	.02219	.99998	.03461	.99982	.64132	1.00000	1.00000
67.000	.02134	.99998	.03336	.99982	.63990	1.00000	1.00000
68.000	.02056	.99998	.03215	.99982	.63963	1.00000	1.00000
69.000	.01981	.99998	.03100	.99982	.63921	1.00000	1.00000
70.000	.01907	.99999	.02990	.99982	.63778	1.00000	1.00000
71.000	.01839	.99999	.02887	.99982	.63718	1.00000	1.00000
72.000	.01772	.99999	.02788	.99982	.63563	1.00000	1.00000
73.000	.01708	.99999	.02694	.99982	.63395	1.00000	1.00000
74.000	.01648	.99999	.02604	.99982	.63292	1.00000	1.00000
75.000	.01588	.99999	.02518	.99982	.63071	1.00000	1.00000
76.000	.01533	.99999	.02435	.99982	.62971	1.00000	1.00000
77.000	.01478	.99999	.02354	.99982	.62796	1.00000	1.00000
78.000	.01426	.99999	.02277	.99982	.62662	1.00000	1.00000
79.000	.01377	1.00000	.02201	.99982	.62563	1.00000	1.00000
80.000	.01328	1.00000	.02128	.99982	.62420	1.00000	1.00000
81.000	.01283	1.00000	.02057	.99982	.62364	1.00000	1.00000
82.000	.01238	1.00000	.01988	.99982	.62254	1.00000	1.00000
83.000	.01195	1.00000	.01922	.99982	.62202	1.00000	1.00000
84.000	.01154	1.00000	.01857	.99982	.62139	1.00000	1.00000
85.000	.01114	1.00000	.01795	.99982	.62077	1.00000	1.00000
86.000	.01076	1.00000	.01734	.99982	.62044	1.00000	1.00000
87.000	.01039	1.00000	.01676	.99982	.61973	1.00000	1.00000
88.000	.01003	1.00000	.01620	.99982	.61942	1.00000	1.00000
89.000	.00969	1.00000	.01566	.99982	.61873	1.00000	1.00000
90.000	.00935	1.00000	.01513	.99982	.61826	1.00000	1.00000
91.000	.00903	1.00000	.01463	.99982	.61766	1.00000	1.00000
92.000	.00872	1.00000	.01414	.99982	.61701	1.00000	1.00000
93.000	.00842	1.00000	.01367	.99982	.61649	1.00000	1.00000
94.000	.00813	1.00000	.01321	.99982	.61572	1.00000	1.00000
95.000	.00786	1.00000	.01277	.99982	.61523	1.00000	1.00000
96.000	.00758	1.00000	.01234	.99982	.61443	1.00000	1.00000
97.000	.00732	1.00000	.01193	.99982	.61392	1.00000	1.00000
98.000	.00707	1.00000	.01153	.99982	.61316	1.00000	1.00000

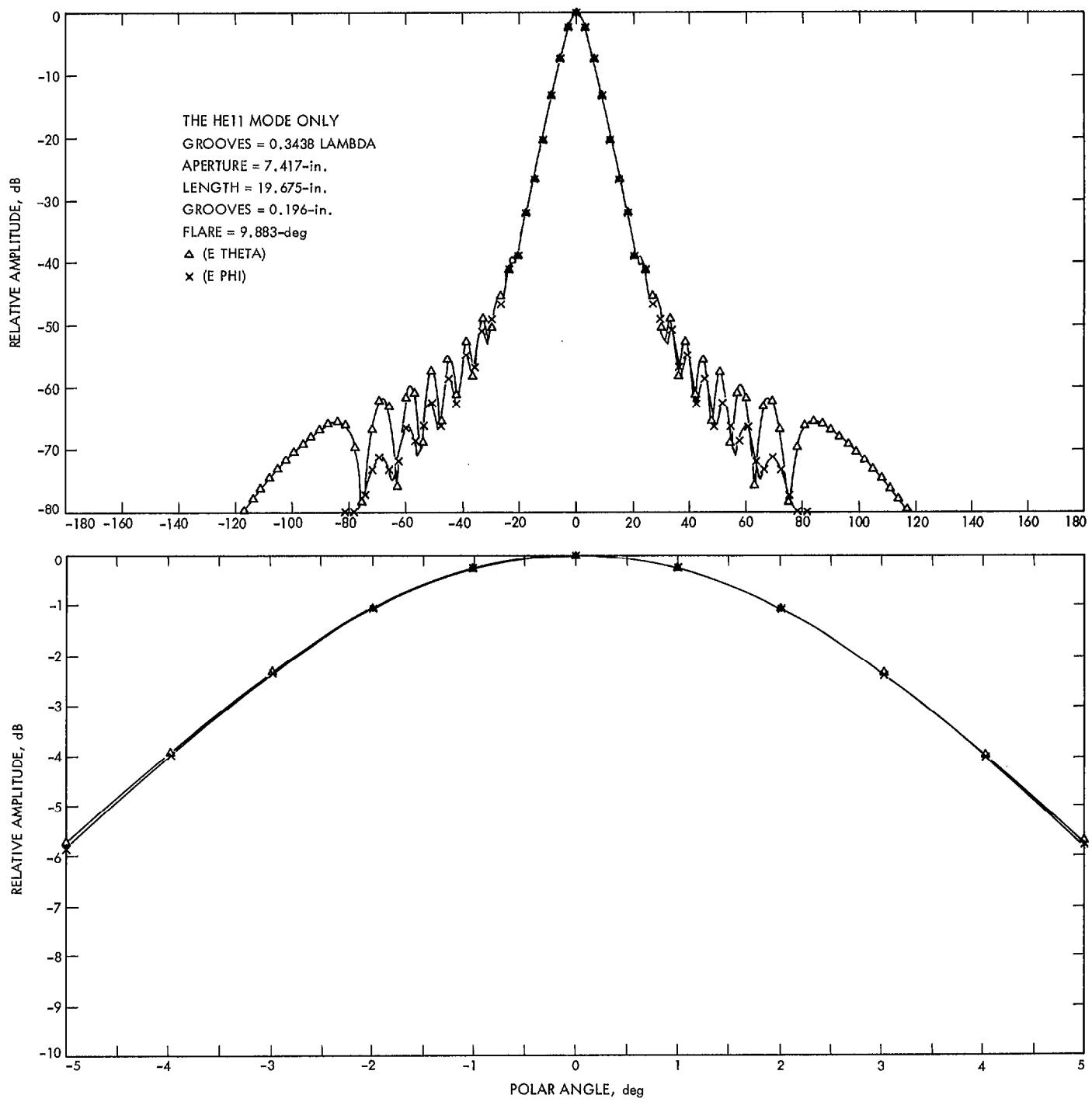
Fig. 2 (contd)

THETA	ETA T (OVERALL)	ETA S (SPILL)	ETA I (ILLUM)	ETA X (X-POL)	ETA P (PHASE)	ETA B (BLOCK)	ETA M (M=1)
99.000	.00682	1.00000	.01114	.99982	.61261	1.00000	1.00000
100.000	.00659	1.00000	.01076	.99982	.61194	1.00000	1.00000
101.000	.00636	1.00000	.01040	.99982	.61135	1.00000	1.00000
102.000	.00613	1.00000	.01004	.99982	.61077	1.00000	1.00000
103.000	.00592	1.00000	.00970	.99982	.61015	1.00000	1.00000
104.000	.00571	1.00000	.00937	.99982	.60965	1.00000	1.00000
105.000	.00551	1.00000	.00904	.99982	.60903	1.00000	1.00000
106.000	.00531	1.00000	.00873	.99982	.60859	1.00000	1.00000
107.000	.00512	1.00000	.00842	.99982	.60801	1.00000	1.00000
108.000	.00494	1.00000	.00813	.99982	.60761	1.00000	1.00000
109.000	.00476	1.00000	.00784	.99982	.60708	1.00000	1.00000
110.000	.00459	1.00000	.00756	.99982	.60670	1.00000	1.00000
111.000	.00442	1.00000	.00729	.99982	.60623	1.00000	1.00000
112.000	.00426	1.00000	.00703	.99982	.60587	1.00000	1.00000
113.000	.00410	1.00000	.00677	.99982	.60545	1.00000	1.00000
114.000	.00394	1.00000	.00652	.99982	.60512	1.00000	1.00000
115.000	.00380	1.00000	.00628	.99982	.60476	1.00000	1.00000
116.000	.00365	1.00000	.00604	.99982	.60445	1.00000	1.00000
117.000	.00351	1.00000	.00582	.99982	.60413	1.00000	1.00000
118.000	.00338	1.00000	.00559	.99982	.60383	1.00000	1.00000
119.000	.00325	1.00000	.00538	.99982	.60355	1.00000	1.00000
120.000	.00312	1.00000	.00517	.99982	.60329	1.00000	1.00000
121.000	.00299	1.00000	.00497	.99982	.60304	1.00000	1.00000
122.000	.00287	1.00000	.00477	.99982	.60280	1.00000	1.00000
123.000	.00276	1.00000	.00458	.99982	.60257	1.00000	1.00000
124.000	.00264	1.00000	.00439	.99982	.60235	1.00000	1.00000
125.000	.00253	1.00000	.00421	.99982	.60214	1.00000	1.00000
126.000	.00243	1.00000	.00404	.99982	.60194	1.00000	1.00000
127.000	.00233	1.00000	.00386	.99982	.60176	1.00000	1.00000
128.000	.00223	1.00000	.00370	.99982	.60158	1.00000	1.00000
129.000	.00213	1.00000	.00354	.99982	.60141	1.00000	1.00000
130.000	.00203	1.00000	.00338	.99982	.60125	1.00000	1.00000
131.000	.00194	1.00000	.00323	.99982	.60109	1.00000	1.00000
132.000	.00185	1.00000	.00309	.99982	.60094	1.00000	1.00000
133.000	.00177	1.00000	.00294	.99982	.60080	1.00000	1.00000
134.000	.00169	1.00000	.00281	.99982	.60066	1.00000	1.00000
135.000	.00160	1.00000	.00267	.99982	.60053	1.00000	1.00000
136.000	.00153	1.00000	.00254	.99982	.60041	1.00000	1.00000
137.000	.00145	1.00000	.00242	.99982	.60028	1.00000	1.00000
138.000	.00138	1.00000	.00230	.99982	.60017	1.00000	1.00000
139.000	.00131	1.00000	.00218	.99982	.60006	1.00000	1.00000
140.000	.00124	1.00000	.00207	.99982	.59995	1.00000	1.00000
141.000	.00117	1.00000	.00196	.99982	.59985	1.00000	1.00000
142.000	.00111	1.00000	.00185	.99982	.59974	1.00000	1.00000
143.000	.00105	1.00000	.00175	.99982	.59965	1.00000	1.00000
144.000	.00099	1.00000	.00165	.99982	.59955	1.00000	1.00000
145.000	.00093	1.00000	.00155	.99982	.59947	1.00000	1.00000
146.000	.00087	1.00000	.00146	.99982	.59936	1.00000	1.00000
147.000	.00082	1.00000	.00137	.99982	.59930	1.00000	1.00000
148.000	.00077	1.00000	.00128	.99982	.59920	1.00000	1.00000
149.000	.00072	1.00000	.00120	.99982	.59913	1.00000	1.00000
150.000	.00067	1.00000	.00112	.99982	.59904	1.00000	1.00000
151.000	.00063	1.00000	.00104	.99982	.59897	1.00000	1.00000

Fig. 2 (contd)

THETA	ETA T (OVERALL)	ETA S (SPILL)	ETA I (ILLUM)	ETA X (X=POI)	ETA P (PHASE)	ETA B (BLOCK)	ETA M (M=1)
152.000	.00058	1.00000	.00097	.99982	.59890	1.00000	1.00000
153.000	.00054	1.00000	.00090	.99982	.59882	1.00000	1.00000
154.000	.00050	1.00000	.00083	.99982	.59877	1.00000	1.00000
155.000	.00046	1.00000	.00077	.99982	.59867	1.00000	1.00000
156.000	.00042	1.00000	.00071	.99982	.59863	1.00000	1.00000
157.000	.00039	1.00000	.00065	.99982	.59853	1.00000	1.00000
158.000	.00035	1.00000	.00059	.99982	.59848	1.00000	1.00000
159.000	.00032	1.00000	.00054	.99982	.59841	1.00000	1.00000
160.000	.00029	1.00000	.00049	.99982	.59834	1.00000	1.00000
161.000	.00026	1.00000	.00044	.99982	.59830	1.00000	1.00000
162.000	.00023	1.00000	.00039	.99982	.59821	1.00000	1.00000
163.000	.00021	1.00000	.00035	.99982	.59816	1.00000	1.00000
164.000	.00018	1.00000	.00031	.99982	.59808	1.00000	1.00000
165.000	.00016	1.00000	.00027	.99982	.59803	1.00000	1.00000
166.000	.00014	1.00000	.00024	.99982	.59796	1.00000	1.00000
167.000	.00012	1.00000	.00020	.99982	.59784	1.00000	1.00000
168.000	.00010	1.00000	.00017	.99982	.59782	1.00000	1.00000
169.000	.00009	1.00000	.00015	.99982	.59769	1.00000	1.00000
170.000	.00007	1.00000	.00012	.99982	.59758	1.00000	1.00000
171.000	.00006	1.00000	.00010	.99982	.59756	1.00000	1.00000
172.000	.00005	1.00000	.00008	.99982	.59739	1.00000	1.00000
173.000	.00003	1.00000	.00006	.99982	.59727	1.00000	1.00000
174.000	.00003	1.00000	.00004	.99982	.59718	1.00000	1.00000
175.000	.00002	1.00000	.00003	.99982	.59702	1.00000	1.00000
176.000	.00001	1.00000	.00002	.99982	.59680	1.00000	1.00000
177.000	.00001	1.00000	.00001	.99982	.59647	1.00000	1.00000
178.000	.00000	1.00000	.00000	.99982	.59620	1.00000	1.00000
179.000	.00000	1.00000	.00000	.99982	.59478	1.00000	1.00000
180.000	.00000	1.00000	.00000	.99982	.00187	1.00000	1.00000
MAXIMUM EFFICIENCY			F/D #3.230				
8.852	.75607	.89877	.84217	.99986	.99907	1.00000	1.00000
GAIN = 27.658 DB = 583.176 = $\sigma_M$ ←							
FEED BLOCKAGE ANGLE = .000 DEGREES							
TOTAL RADIATED POWER FOR GIVEN PATTERN = .286053-04 WATTS							
TOTAL RADIATED POWER REFERENCE PATTERN = .286053-04 WATTS							
ETAR = 1.00000 (GIVEN PAT. POWER / REF. PAT. POWER)							
NUMBER OF TERMS USED IN INTERPOLATIONS = 3							
EFFICIENCY CALCULATED FOR M = (1, EVEN) CASE ONLY							
FREQ=.31.4GHZ, GROOVES=.0.3263LAMBDA 0							
4.720INCH, APERTURE=.12.451INCH LONG=.0.125INCH GROOVES,.9.883 DEG FLARE							

Fig. 2 (contd)



**Fig. 3. 20.7-GHz horn computer plot**

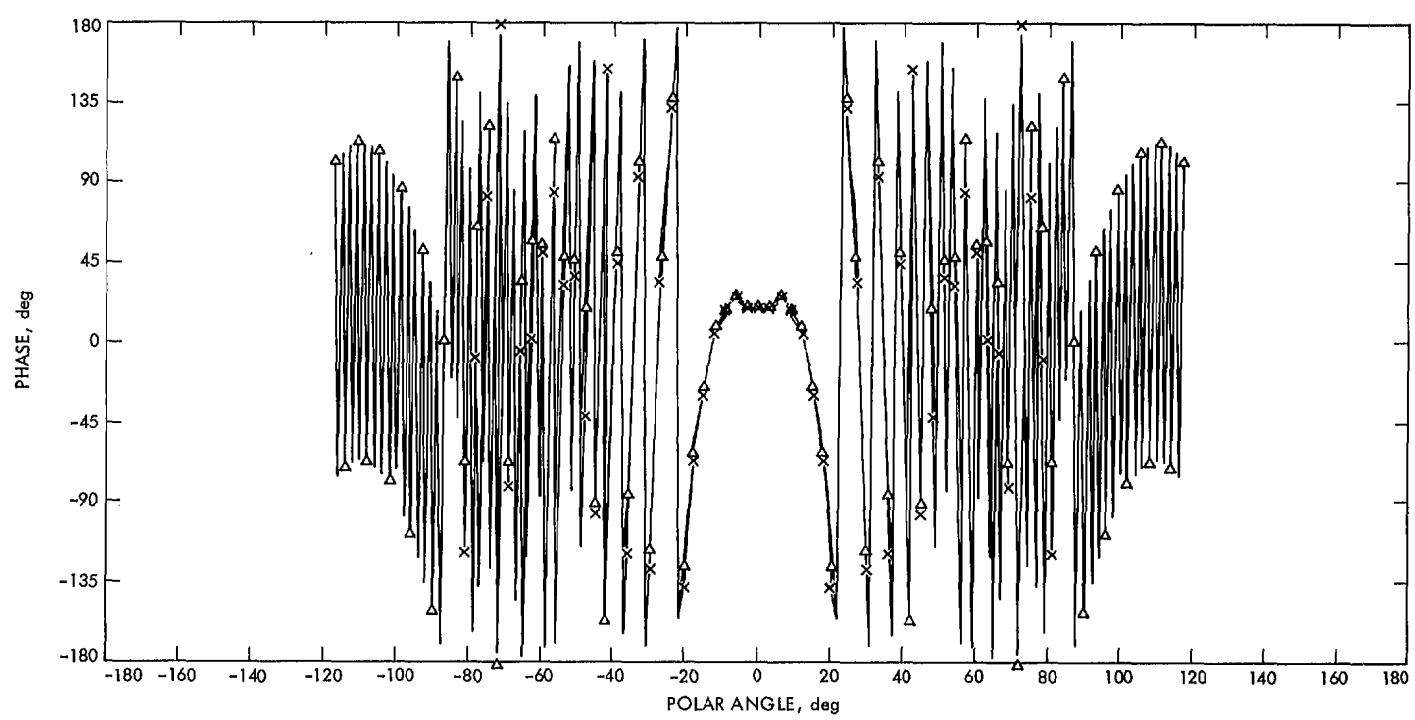


Fig. 3 (contd)

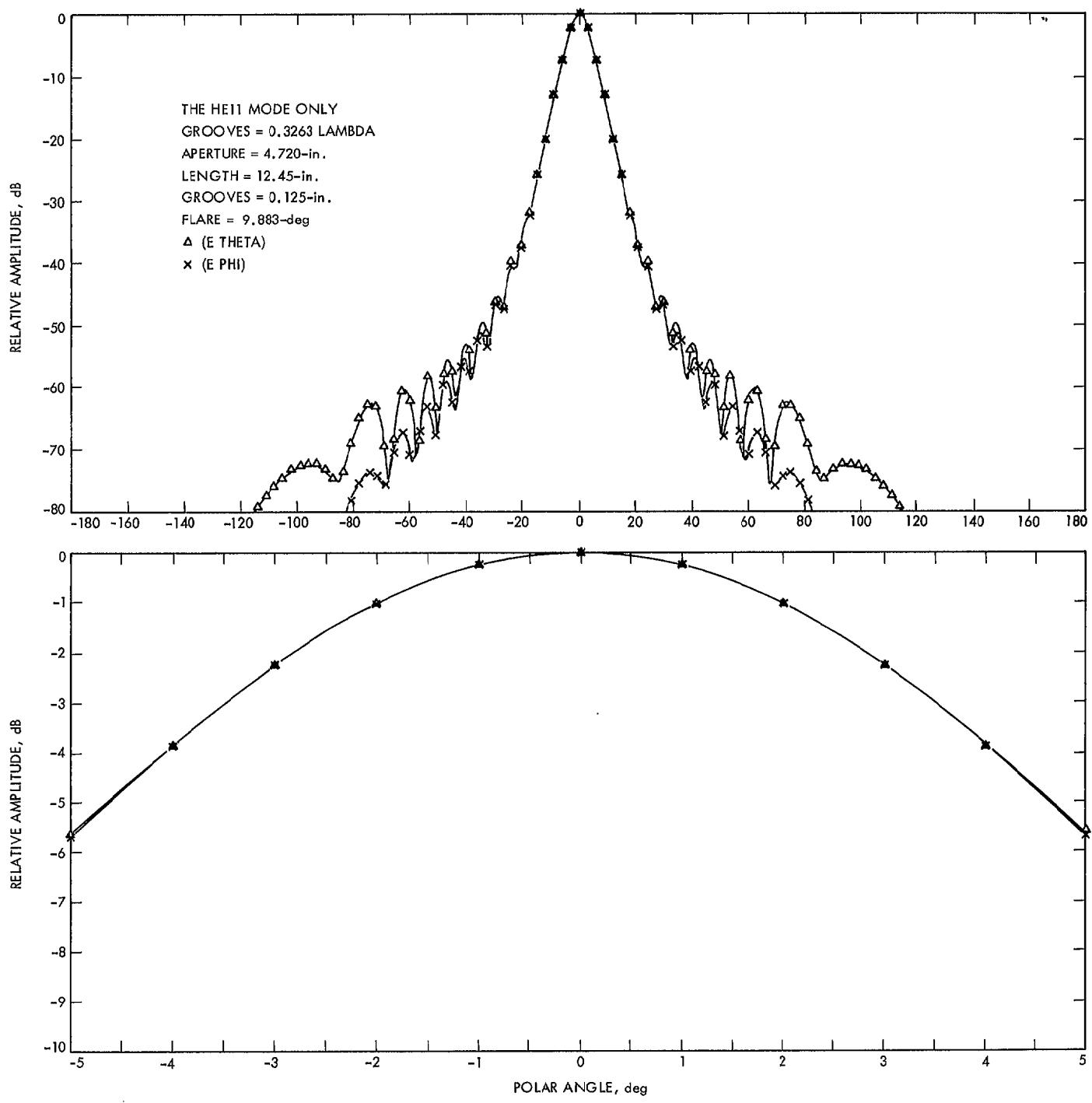


Fig. 4. 31.4-GHz horn computer plot

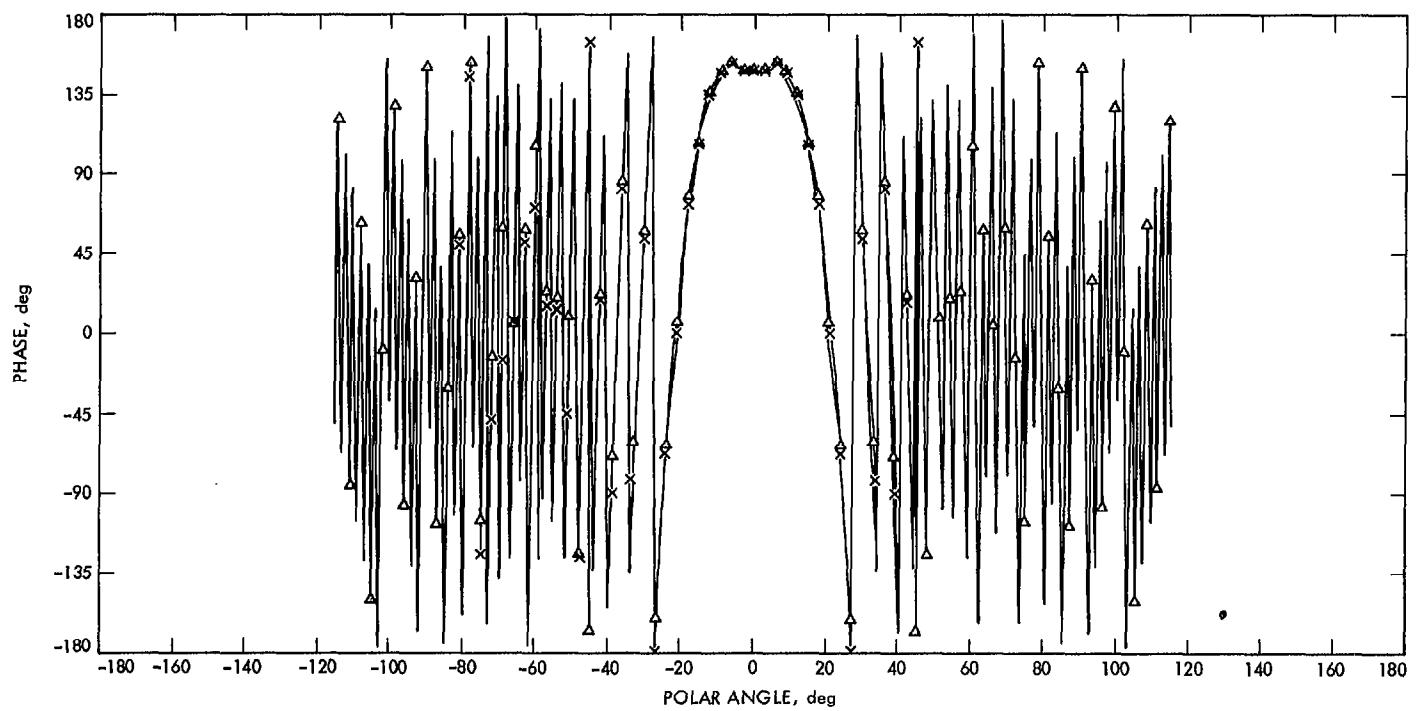


Fig. 4 (contd)

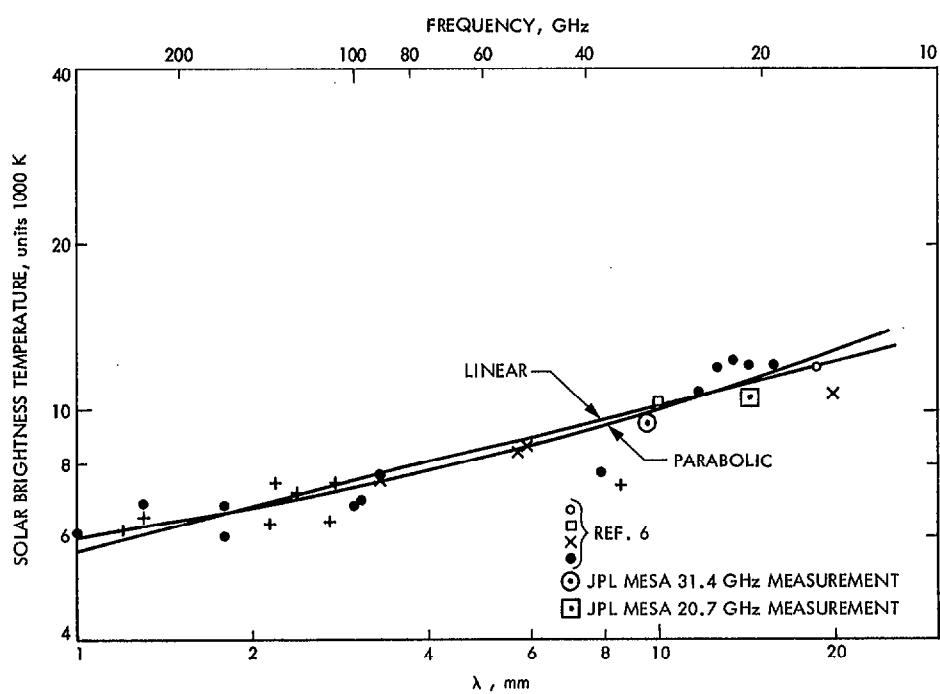


Fig. 5. Comparison of JPL Mesa WVR-R06 solar noise temperature measurements with those taken at other frequencies (Ref. 6, Fig. 2)

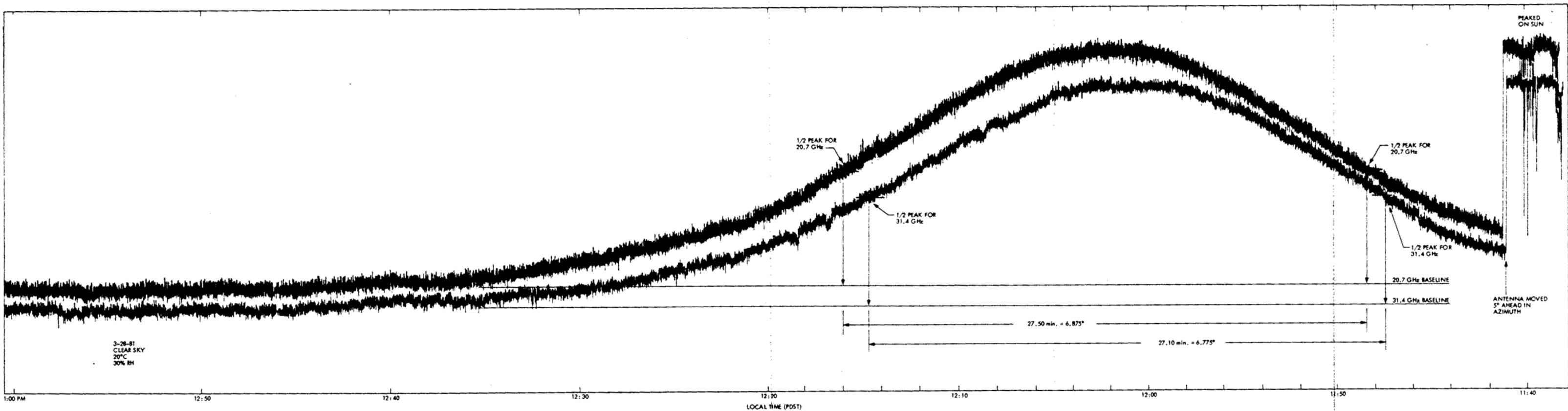


Fig. 6. Experimental drift curves of the 20.7/31.4 GHz radiometers (WVR-R04) taken at DSS13 at meridian crossing using the sun as a source